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INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS,
NEXT-GENERATION NETWORKS, INTERNET OF
THINGS AND SMART CITIES

Internet of things and smart cities and communities –
Evaluation and assessment

**Key performance indicators for smart
sustainable cities to assess the achievement of
sustainable development goals**

Recommendation ITU-T Y.4903

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Recommendation ITU-T Y.4903

Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals

Summary

Recommendation ITU-T Y.4903 provides key performance indicators (KPIs) for smart sustainable cities (SSCs) and general principles for selecting KPIs to help cities achieve sustainable development goals (SDGs).

This Recommendation provides a means to benchmarking and disseminating best practices in utilizing ICTs and other technologies to enhance cities' sustainability and connect their smart strategies to the SDGs through an inclusive process.

These KPIs are designed to evaluate the role and performance of information communication technologies (ICTs) in the three dimensions of a city: economics, environment, and society and culture. The indicators are uniquely coordinated to allow cities to measure their progress on reaching the ambitious targets set by the SDGs.

History

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Introduction

These key performance indicators for smart sustainable cities have been developed to provide cities with a consistent and standardised method to collect data and measure the performance and progress of:

- achieving the Sustainable Development Goals (SDGs);
- becoming a smarter city; and
- becoming a more sustainable city.

The indicators enable cities to measure their progress over time, compare their performance to other cities and through analysis and sharing allow for the dissemination of best practices and set standards for progress in meeting the SDGs at the city level.

Each indicator forms part of a holistic view of a city's performance in three dimensions; economy, environment, and society and culture. Each of these dimensions provides a separate view of progress and when reported together provides a holistic view of a smart sustainable city (SSC).

Within each dimension, there are sub-dimensions that focus on more specific areas of performance and progress. An example is the ICT Infrastructure sub-dimension which provides a more in-depth view of how ICTs are deployed and used within a city.

The indicators are further subdivided into core and advanced indicators. Core indicators are those that should be able to be reported on by all cities. They provide a basic outline of smartness and sustainability, and higher levels of performance can generally be achievable. Advanced indicators provide a more in-depth view of a city and measure progress on more advanced initiatives; however, they may be beyond the current capabilities of some cities to report or implement.

Each indicator has been chosen through a process of review and input by ITU members as well as international experts and UN agencies, programmes and secretariats to ensure that the data collected supports the SDGs, is relevant to measuring progress to becoming smarter and more sustainable.

To ensure that cities are more easily able to collect data and to ensure that reported indicator values are consistent, each indicator has a description for:

- the rationale for choosing the indicator;
- how the indicator should be interpreted;
- what benchmarking trends are considered desirable;
- the methodology for calculating the value to be reported; and
- potential sources of data.

This collection methodology for the key performance indicators for smart sustainable cities provides cities with a methodology on how to collect data or information from key performance indicators (KPIs) for smart sustainable cities. This set of KPIs for SSC was developed to establish the criteria to assess the smartness and sustainability of a city, and to provide cities with the means for self-assessments towards SDGs.

Recommendation ITU-T Y.4903

Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals

1 Scope

This Recommendation outlines the key performance indicators (KPIs) for smart sustainable cities (SSCs) and establishes the criteria to evaluate ICT's contributions in making cities smarter and more sustainable and provide cities with the means for self-assessment in order to achieve the sustainable development goals (SDGs). Evaluating these indicators can help cities as well as their stakeholders understand to what extent they may be perceived as achieving their smart and sustainable goals. This Recommendation is expected to drive corporations and partnerships at all levels in unlocking the full potential of cities' smart strategies, developing transformative solutions to tackle smart sustainable cities' challenges and achieving the SDGs. The KPIs are based on key dimensions of a city: economics, environment, and society and culture.

This Recommendation is aimed at cities and related administrations, but can be utilized by a variety of stakeholders, such as public and private partners and academia, to enable strategy development, information sharing, understand the city's progress, and assess the SSC's development.

The intention of identifying the KPIs is to establish a means to evaluate cities' performances and their progress towards becoming smarter and more sustainable and to provide the cities with the means for self-assessments. Cities are encouraged to periodically check their performances against the recommended indicators listed in this Recommendation in order to improve their performance. These KPIs are not intended to be used for the cross-evaluation of cities with respect to their performance and progress becoming smarter and more sustainable.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.4901] Recommendation ITU-T Y.4901/L.1601 (2016), *Key performance indicators related to the use of information and communication technology in smart sustainable cities*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 city [b-ITU-T Y.4900]: An urban geographical area with one (or several) local government and planning authorities.

3.1.2 ICT companies [ITU-T Y.4901]: Companies which provide products and/or services with respect to information and communication technologies.

3.1.3 key performance indicator [b-ITU-T Y.4051]: Indicators representing the resource usage effectiveness or efficiency of a given system.

3.1.4 knowledge economy [b-OECD KE]: Economies which are directly based on the production, distribution and use of knowledge and information.

3.1.5 smart sustainable city [b-ITU-T Y.4900]: A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural aspects.

NOTE – City competitiveness refers to policies, institutions, strategies and processes that determine the city's sustainable productivity.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AQI	Air Quality Index
BEV	Battery Electric Vehicle
BMI	Body Mass Index
BPL	Broadband-over-Power Line
CAIDI	Customer Average Interruption Duration Index
CO ₂	Carbon Dioxide
COP	Child Online Protection
EU	European Union
EV	Electric Vehicle
FAO	Food and Agriculture Organisation
FCEV	Fuel Cell Electric Vehicle
GDP	Gross Domestic Product
GDWQ	Guidelines for Drinking Water Quality
GHG	Greenhouse Gas
ICD	International Classification of Diseases
ICT	Information and Communication Technology
IP	Internet Protocol
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LAN	Local Area Network
OECD	Organization for Economic Co-operation and Development
PHEV	Plug-in Hybrid Electric Vehicle
PM ₁₀	Particulate Matter up to 10 micrometres in size
PM _{2.5}	Particulate Matter up to 2.5 micrometres in size
PPP	Purchasing Power Parity

QoL	Quality of Life
R&D	Research and Development
RAMOS	Reproductive-Age Mortality Studies
REEV	Range Extended Electric Vehicle
REX	Range Extender
RTU	Remote Terminal Unit
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable Development Goal
SMEs	Small and Medium-sized Enterprises
SSC	Smart Sustainable Cities
TCP	Transmission Control Protocol
UITP	International Association of Public Transport
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
USD	United States Dollars
WHO	World Health Organization

5 Conventions

None.

6 General principles for selecting key performance indicators

The selection of KPIs is based on the following principles:

- Independent: The KPIs should be independent or almost-orthogonal (i.e., overlap of the KPIs should be avoided as much as possible) and changes to an indicator should not impact the evaluation of or preferences given to other indicators.
- Reliable: The concept of each indicator should be clear, simple and easy to understand. A widely-accepted definition of the KPI not open to different interpretations assists different users to interpret it in the same way. Also, the calculation of the associated data should be intuitive and simple.
- Measurable: The KPIs should be defined in a way that the value can be measured and comparable scientifically between different phases of urban development, which means the KPIs should be comparable over time and space. The measurement should be as objective as possible. The historic and current data should be either available or easy to collect.
- Achievable: The goal of the KPIs should be achievable and the set of indicators should cover relevant aspects of the SSC. It should also be possible to extend and amend the set of KPIs according to the actual stage of development.
- Relevant: The KPIs should provide insight into the progress of the city in obtaining goals and executing its strategy. The indicators for evaluation should be aligned to the measured subject. The index system should reflect the level of general development for a particular aspect.

- Timely: It is important to express the value of the KPI over time. Every KPI has a meaning only if the time dimension in which it is realized is known. KPIs are also able to deal with emerging issues in SSC construction.

7 Key performance indicators structure

This section contains the structure of the key performance indicators and is divided into three dimensions:

- economy
- environment
- society and culture.

Table 1 – List of KPIs on economy dimension

Dimension	Sub-dimension	Category	KPI	Type	Type
Economy	ICT	ICT infrastructure	Household Internet access	Core	SMART
			Fixed broadband subscriptions	Core	SMART
			Wireless broadband subscriptions	Core	SMART
			Wireless broadband coverage	Core	SMART
			Availability of WIFI in public areas	Advanced	SMART
		Water and sanitation	Smart water meters	Core	SMART
			Water supply ICT monitoring	Advanced	SMART
		Drainage	Drainage/Storm water system ICT monitoring	Advanced	SMART
		Electricity supply	Smart electricity meters	Core	SMART
			Electricity supply ICT Monitoring	Advanced	SMART
			Demand response penetration	Advanced	SMART
		Transport	Dynamic public transport information	Core	SMART
			Traffic monitoring	Core	SMART
			Intersection control	Advanced	SMART
		Public sector	Open data	Advanced	SMART
			e-government	Advanced	SMART
			Public sector e-procurement	Advanced	SMART
	Productivity	Innovation	R&D expenditure	Core	STRUCTURAL
			Patents	Core	STRUCTURAL
			Small and medium-sized enterprises	Advanced	STRUCTURAL
		Employment	Unemployment rate	Core	STRUCTURAL
			Youth unemployment rate	Core	STRUCTURAL
			Tourism sector employment	Advanced	STRUCTURAL
			ICT sector employment	Advanced	STRUCTURAL

Table 1 – List of KPIs on economy dimension

Dimension	Sub-dimension	Category	KPI	Type	Type
Economy	Infrastructure	Water and sanitation	Basic water supply	Core	SUSTAINABLE
			Potable water supply	Core	SUSTAINABLE
			Water supply loss	Core	SUSTAINABLE
			Waste-water collection	Core	SUSTAINABLE
			Household sanitation	Core	SUSTAINABLE
		Waste	Solid waste collection	Core	SUSTAINABLE
		Electricity supply	Electricity system outage frequency	Core	STRUCTURAL
			Electricity system outage time	Core	STRUCTURAL
			Access to electricity	Core	STRUCTURAL
		Transport	Public transport network	Core	SUSTAINABLE
			Public transport network convenience	Advanced	SUSTAINABLE
			Bicycle network	Core	SUSTAINABLE
			Transportation mode share	Advanced	SUSTAINABLE
			Travel time index	Advanced	SUSTAINABLE
			Shared bicycles	Advanced	SUSTAINABLE
			Shared vehicles	Advanced	SUSTAINABLE
			Low-carbon emission passenger vehicles	Advanced	SUSTAINABLE
		Buildings	Public building sustainability	Advanced	SUSTAINABLE
			Integrated building management systems in public buildings	Advanced	SMART
		Urban planning	Pedestrian infrastructure	Advanced	SUSTAINABLE
			Urban development and spatial planning	Advanced	SUSTAINABLE

Table 2 – List of KPIs on environment dimension

Dimension	Sub-dimension	Category	KPI	Type	Type
Environment	Environment	Air quality	Air pollution	Core	SUSTAINABLE
			GHG emissions	Core	SUSTAINABLE
		Water and sanitation	Drinking water quality	Core	SUSTAINABLE
			Water consumption	Core	SUSTAINABLE
			Freshwater consumption	Core	SUSTAINABLE
			Waste-water treatment	Core	SUSTAINABLE
		Waste	Solid waste treatment	Core	SUSTAINABLE
		Environmental quality	EMF exposure	Core	SUSTAINABLE
			Noise exposure	Advanced	SUSTAINABLE
		Public space and nature	Green areas	Core	SUSTAINABLE
			Green area accessibility	Advanced	SUSTAINABLE
			Protected natural areas	Advanced	SUSTAINABLE
			Recreational facilities	Advanced	SUSTAINABLE
	Energy	Energy	Renewable energy consumption	Core	SUSTAINABLE
			Electricity consumption	Core	SUSTAINABLE
			Residential thermal energy consumption	Core	SUSTAINABLE
			Public building energy consumption	Core	SUSTAINABLE

Table 3 – List of KPIs on society and culture dimension

Dimension	Sub-dimension	Category	KPI	Type	Type
Society and culture	Education, health and culture	Education	Student ICT access	Core	SMART
			School enrolment	Core	STRUCTURAL
			Higher education degrees	Core	STRUCTURAL
			Adult literacy	Core	STRUCTURAL
		Health	Life expectancy	Core	STRUCTURAL
			Maternal mortality rate	Core	STRUCTURAL
			Physicians	Core	STRUCTURAL
			In-patient hospital beds	Advanced	STRUCTURAL
			Health insurance/ Public health coverage	Advanced	STRUCTURAL
			Electronic health records	Advanced	SMART
		Culture	Cultural expenditure	Core	STRUCTURAL
			Cultural infrastructure	Advanced	STRUCTURAL
	Safety, housing and social inclusion	Housing	Informal settlements	Core	STRUCTURAL
			Housing expenditure	Advanced	STRUCTURAL
		Social inclusion	Gender income equity	Core	STRUCTURAL
			Gini coefficient	Core	STRUCTURAL
			Poverty	Core	STRUCTURAL
			Voter participation	Core	STRUCTURAL
			Childcare availability	Advanced	STRUCTURAL
		Safety	Natural disaster-related deaths	Core	SUSTAINABLE
			Disaster-related economic losses	Core	SUSTAINABLE
			Resilience plans	Advanced	SUSTAINABLE

Table 3 – List of KPIs on society and culture dimension

Dimension	Sub-dimension	Category	KPI	Type	Type
			Population living in disaster-prone areas	Advanced	SUSTAINABLE
			Emergency service response time	Advanced	STRUCTURAL
			Police service	Core	STRUCTURAL
			Fire service	Core	STRUCTURAL
			Violent crime rate	Core	STRUCTURAL
			Traffic fatalities	Core	STRUCTURAL
		Food security	Local food production	Advanced	SUSTAINABLE

8 Key performance indicators numbering convention

The following table contains the structure of how the KPI labels (KPI No.) have been attributed.

Table 4 – KPI numbering convention

XX –		X(XX):		X(XX):		Number	C or A
Dimension		Sub-dimension		Category		1, 2, 3, etc.	C: Core A: Advanced
EC	Economy	E	Energy	AQ	Air Quality		
EN	Environment	EH	Education, Health and Culture	B	Buildings		
SC	Society and culture	EN	Environment	C	Culture		
		I	Infrastructure	D	Drainage		
		ICT	ICT	E	Energy		
		P	Productivity	ED	Education		
		SH	Safety, Housing and Social Inclusion	EM	Employment		
				EQ	Environmental Quality		
				ES	Electricity Supply		
				FS	Food Security		
				H	Health		
				HO	Housing		
				IN	Innovation		
				ICT	ICT Infrastructure		
				PS	Public Sector		
				PSN	Public Spaces and Nature		
				SA	Safety		
				SI	Social Inclusion		
				T	Transport		
				UP	Urban Planning		
				WA	Waste		
				WS	Water and Sanitation		

9 Key performance indicators – Economy dimension

The following section contains the indicators related to the economy dimension.

Dimension	Economy				
Sub-dimension	ICT				
Category	ICT infrastructure				
KPI name	Household Internet access				
KPI No.	EC: ICT: ICT: 1C	Type:	Core	Type:	Smart
Definition/ Description	Percentage of households with Internet access				
Rationale/ Interpretation/ Benchmarking	This indicator demonstrates the access to information and technology connectivity given that connectivity across regions and between countries is correlated to economic prosperity, development and growth. This in turn underscores a city inhabitant's access to knowledge, data, news and communication to use for economic productivity, i.e., training, education, research, business management, ideas exchange, etc. Data that includes any household's access via a fixed or mobile network at any given time should be collected. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: number of households with Internet access. Denominator: total number of households. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	The data may be collected from the local statistics department or may need to be extrapolated from national data. Annual surveys of households may be another method for data collection to obtain the percentage of households with Internet access. This percentage will then be applied to the in-scope population. The data may also be collected from local Internet service providers and telecommunications companies.				
SDG reference(s)	SDG indicator 17.8.1: Proportion of individuals using the Internet.				

Dimension	Economy				
Sub-dimension	ICT				
Category	ICT infrastructure				
KPI name	Fixed broadband subscriptions				
KPI No.	EC: ICT: ICT: 2C	Type:	Core	Type:	Smart
Definition/ Description	Percentage of households with fixed (wired) broadband				
Rationale/ Interpretation/ Benchmarking	This indicator demonstrates the access to information and technology connectivity and is important given that connectivity across regions, and between countries, is correlated to economic prosperity, development and growth. Moreover, penetration into households means that communication is possibly received through multiple mediums such as the Internet, cable, etc. A higher penetration rate means that more of the population has access to knowledge and communications, as well as technologies to receive and send information and communications (i.e., mobile phones, computers, television, etc.). The average penetration rate (according to OECD) is about 30%. Fixed (wired) broadband subscriptions refer to subscriptions for high-speed access to the public Internet (a TCP/IP connection). High-speed access is defined as a downstream speed equal to, or greater than, 256 kbits/s. Fixed (wired) broadband includes broadband through cable modem, DSL, fibre and other fixed (wired) broadband technologies (such as Ethernet LAN, and broadband-over-power line (BPL) communications). Mobile cellular network subscriptions are not included. An increasing trend and higher values are considered positive.				
Source(s)	NOTE – OECD Statistics. Retrieved from < http://www.oecd.org/sti/broadband/broadband-statistics-update.htm >				
Methodology	Calculate as: Numerator: number of fixed broadband subscriptions. Denominator: total number of households. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	The data may be collected from local statistics department or may need to be extrapolated from national data. Data may also be collected from local Internet service providers and telecommunications companies.				
SDG reference(s)	SDG indicator 17.6.2: Fixed Internet broadband subscriptions per 100 inhabitants, by speed. SDG indicator 17.8.1: Proportion of individuals using the Internet.				

Dimension	Economy				
Sub-dimension	ICT				
Category	ICT infrastructure				
KPI name	Wireless broadband subscriptions				
KPI No.	EC: ICT: ICT: 3C	Type:	Core	Type:	Smart
Definition/ Description	Wireless broadband subscriptions per 100 000 inhabitants				
Rationale/ Interpretation/ Benchmarking	This indicator demonstrates the access to information and technology connectivity and is important given that connectivity across regions and between countries is correlated to economic prosperity, development and growth. At the same time, this indicator reveals the level of advancement of connectivity technology available to the population. This in turn indicates the breadth of sophisticated communication and connectivity technology used. A higher penetration rate means that more of the population have access to knowledge and communication, as well as technology (i.e., mobile phones, computers, television, etc.) to receive and send information and communications. Wireless broadband subscriptions include wireless broadband through satellite broadband, terrestrial fixed wireless broadband and mobile cellular network subscriptions. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: number of wireless broadband subscriptions. Denominator: one 100 000th of the city's population.				
Unit	Number/100 000 inhabitants				
Data sources/ Relevant databases	The data may be collected from local statistics departments or may need to be extrapolated from national data. The data may also be collected from local Internet service providers and telecommunications companies.				
SDG reference(s)	SDG indicator 17.8.1: Proportion of individuals using the Internet. SDG indicator 9.C.1: Percentage of population covered by a mobile network, by technology. SDG indicator 5.B.1: Proportion of individuals who own a mobile telephone, by sex.				

Dimension	Economy				
Sub-dimension	ICT				
Category	ICT infrastructure				
KPI name	Wireless broadband coverage				
KPI No.	EC: ICT: ICT: 4C	Type:	Core	Type:	Smart
Definition/ Description	Percentage of the city served by wireless broadband (3G, 4G and 5G)				
Rationale/ Interpretation/ Benchmarking	This indicator demonstrates the access to information and technology connectivity and is important given that connectivity across regions and between countries is correlated to economic prosperity, development and growth. Smart city applications in many cases are accessed through mobile applications. In order to use these applications in an efficient manner, high speed mobile Internet capabilities are required. The coverage of high-speed mobile Internet from providers is key to enable these capabilities. A value of 100% coverage should be pursued for at least 3G networks. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: area of city covered by mobile services (km²). Denominator: total area of the city (km²). Multiply by 100. Each service should be reported on separately (3G, 4G and 5G).				
Unit	Percentage				
Data sources/ Relevant databases	Data may be collected from local mobile service providers.				
SDG reference(s)	SDG indicator 17.8.1: Proportion of individuals using the Internet. SDG indicator 9.C.1: Percentage of population covered by a mobile network, by technology. SDG indicator 5.B.1: Proportion of individuals who own a mobile telephone, by sex.				

Dimension	Economy				
Sub-dimension	ICT				
Category	ICT infrastructure				
KPI name	Availability of Wi-Fi in public areas				
KPI No.	EC: ICT: ICT: 5A	Type:	Advanced	Type:	Smart
Definition/ Description	Number of public Wi-Fi hotspots in the city				
Rationale/ Interpretation/ Benchmarking	Several mega-cities have set-up Wi-Fi hotspots at public venues, thereby providing travelling users, as well as their citizens, with increased access to Internet at little or no cost. Such actions empower citizens and promotes the use of e-services without the burden of network costs. Cities should report only those Wi-Fi spots operated by the city (or on behalf of the city) that are free of charge.				
Source(s)	[ITU-T Y.4901] NOTE 1 – United Nations E-Government Survey 2020. Retrieved from https://www.un.org/development/desa/publications/publication/2020-united-nations-e-government-survey NOTE 2 – Connecting the Unconnected: Working together to achieve the Connect 2020 Agenda targets. Retrieved from http://broadbandcommission.org/Documents/ITU_discussion-paper_Davos2017.pdf				
Methodology	Calculate as: Total number of Wi-Fi hotspots provided by the city administration (excluding commercial entities)				
Unit	Number				
Data sources/ Relevant databases	Information can be derived from: i) information Wi-Fi hotspots from a telecommunications regulatory agency/ ICT ministry; tourism agencies, Wi-Fi hotspots service providers, etc.; ii) city administration or national entity of statistics and census. Collection method: This information can be gathered from: 1) WIFI service provider statistics; 2) databases.				
SDG reference(s)	SDG target 9.C: Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Water and sanitation				
KPI name	Smart water meters				
KPI No.	EC: ICT: WS: 1C	Type:	Core	Type:	Smart
Definition/ Description	Percentage implementation of smart water meters				
Rationale/ Interpretation/ Benchmarking	Water is becoming an increasingly scarce commodity and many cities are located in areas where water shortages exist. Future trends also indicate that this problem will persist in these areas. The conservation of water resources is key to the long-term sustainability of cities and the use of smart water meters can allow for better monitoring of water consumption patterns. A smart water meter is an electronic device that provides real-time measurement of water consumption and transmits those measurements to water utility providers and customers. These measurements can be effective in some conservation programmes (such as leak detection) and for providing information to customers on their consumption habits. An increasing trend in implementation and higher values are considered positive.				
Source(s)	NOTE – Smart Meters and Domestic Water Usage. Retrieved from http://www.fwr.org/econom/SmartMeters.pdf				
Methodology	Calculate as: Numerator: number of smart water meters installed. Denominator: total number of water meters installed. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected from local water utilities.				
SDG reference(s)	SDG target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity. SDG indicator 6.4.1: Change in water-use efficiency over time.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Water and sanitation				
KPI name	Water supply ICT monitoring				
KPI No.	EC: ICT: WS: 2A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage of the water distribution system monitored by ICT				
Rationale/ Interpretation/ Benchmarking	The city should report on the extent that a supervisory control and data acquisition (SCADA) system (or similar system) has been implemented to cover the water supply system. The system may include the following features: ▪ central control facility; ▪ level transducers that track water levels in reservoirs and tanks; ▪ pressure transducers in pipes that ensure that water is pumped and is flowing efficiently; ▪ flowmeters that measure the actual delivery of water; and ▪ pressure-sustaining and pressure-reducing valves that open and close incrementally to adjust the rate at which the water flows. ICT control has shown to be effective in improving the efficiency of a water supply system and an effective tool for determining areas of water loss. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: length of system monitored by ICT (km). Denominator: total length of total system (km). Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected from local water utilities.				
SDG reference(s)	SDG target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity. SDG indicator 6.4.1: Change in water-use efficiency over time.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Drainage				
KPI name	Drainage / Storm water system ICT monitoring				
KPI No.	EC: ICT: D: 1A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage of drainage/storm water system monitored by ICT				
Rationale/ Interpretation/ Benchmarking	Optimal control techniques in urban drainage networks help generate control strategies ahead of time, based on current and past readings of the telemetry system, to minimize flooding and control sewer overflow. Real-time control of an urban drainage system may be local or global. When local control is applied, flow regulation devices only use measurements taken at its specific location. While this control structure is applicable in many simple cases, in a large city, with an interconnected sewerage network and a complex network of actuators and sensors, it may not be the most efficient alternative. Conversely, global control, which computes control actions taking into account real-time measurements all through the network, is likely to make the best use of the infrastructure capacity and all the available sensor information. ICT control has shown to be effective in improving the efficiency of a drainage system and can minimize instances of urban flooding. An increasing trend and higher values are considered positive.				
Source(s)	NOTE – Optimal control of urban drainage systems. Retrieved from http://www.iri.upc.edu/files/scidoc/680-Optimal-control-of-urban-drainage-systems.-A-case-study.pdf				
Methodology	Calculate as: Numerator: length of system monitored by ICT (km). Denominator: total length of total system (km). Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected from local authorities responsible for drainage.				
SDG reference(s)	SDG target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Electricity supply				
KPI name	Smart electricity meters				
KPI No.	EC: ICT: ES: 1C	Type:	Core	Type:	Smart
Definition/ Description	Percentage implementation of smart electricity meters				
Rationale/ Interpretation/ Benchmarking	The implementation of smart meters allows for a more direct and real-time measurement of the load on an electricity grid and the consumption habits of consumers. Real-time data can allow for more real-time pricing of electricity and the implementation of tools to manage energy usage and peak demand. A smart electricity meter is an electronic device that provides more real-time measurements related to electricity consumption and transmits those measurements directly to electricity utility providers and customers. These measurements can be effective in some conservation programmes, such as demand management and for providing information to customers on their consumption habits. An increasing trend in implementation and higher values are considered positive.				
Source(s)	NOTE – Department of Energy. Electric Meters. Retrieved from < https://energy.gov/energysaver/electric-meters >				
Methodology	Calculate as: Numerator: number of smart electricity meters installed. Denominator: total number of electricity meters installed. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected through the local electrical utility.				
SDG reference(s)	SDG target 7.3: By 2030, double the global rate of improvement in energy efficiency.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Electricity supply				
KPI name	Electricity supply ICT monitoring				
KPI No.	EC: ICT: ES: 2A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage of electricity supply system monitored by ICT				
Rationale/ Interpretation/ Benchmarking	The city should report on the extent that a supervisory control and data acquisition (SCADA) system (or similar system) has been implemented to cover the electricity supply system. Modern SCADA systems replace the manual labour to perform electrical distribution tasks and manual processes in distribution systems with automated equipment. SCADA maximizes the efficiency of power distribution systems by providing features such as real-time views into the operations, data trending and logging, maintenance of desired voltages, currents and power factors, alarms generation, etc. SCADA performs automatic monitoring, protecting and controlling of various equipment in distribution systems with the use of intelligent electronic devices (or RTUs). It restores the power service during fault conditions and also maintains the desired operating conditions. SCADA improves the reliability of supply by reducing duration of outages while providing cost-effective operations of the distribution system. Therefore, SCADA supervises the entire electrical distribution system. The major functions of SCADA can be categorized into the following types: ▪ substation control; ▪ feeder control; and ▪ end user load control. ICT control has shown to be effective in improving the efficiency of an electricity supply system. An increasing trend and higher values are considered positive.				
Source(s)	NOTE – SCADA Systems for Electrical Distribution. Retrieved from http://www.electricaltechnology.org/2015/09/scada-systems-for-electrical-distribution.html#components_of_typical_scada_system				
Methodology	Calculate as: Numerator: length of system monitored by ICT (km). Denominator: total length of total system (km). Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected through the local electrical utility.				
SDG reference(s)	SDG target 7.3: By 2030, double the global rate of improvement in energy efficiency.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Electricity supply				
KPI name	Demand response penetration				
KPI No.	EC: ICT: ES: 3A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage of electricity customers with demand response capabilities				
Rationale/ Interpretation/ Benchmarking	Demand response provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. Demand response programmes are being used by some electric system planners and operators as resource options for balancing supply and demand. Demand response is defined as "changes in electricity use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." (Federal Energy Regulatory Commission). An increasing trend and higher values are considered positive.				
Source(s)	NOTE – Federal Energy Regulatory Commission. Demand Response and Advance Metering. Retrieved from < https://www.ferc.gov/industries-data/electric/power-sales-and-markets/demand-response/reports-demand-response-and >				
Methodology	Calculate as: Numerator: number of demand response enabled electricity customers. Denominator: total number of electricity customers. Multiply by 100				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected through the local electrical utility.				
SDG reference(s)	SDG target 7.3: By 2030, double the global rate of improvement in energy efficiency.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Transport				
KPI name	Dynamic public transport information				
KPI No.	EC: ICT: T: 1C	Type:	Core	Type:	Smart
Definition/ Description	Percentage of urban public transport stops for which traveller information is dynamically available to the public in real time				
Rationale/ Interpretation/ Benchmarking	Traffic congestion is becoming a major problem in many global cities and cities are investing in public transport as one of the most efficient ways to move people around the city. Providing riders with information on the status of the system along with the arrival and travel times (i.e., dynamic information) will encourage transit use. The information reported for each stop must contain at least the arrival of the next vehicle/train/etc. It is also encouraged to provide travel times to other destinations. The information can be provided at the stop itself through screens or through other electronic means such as the official website or a mobile application. The information should be dynamic so that it is current and updated regularly rather than simply being posted as a static timetable. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: number of stops and stations with dynamic information available. Denominator: total number of stops and stations. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected from transportation agencies serving the city.				
SDG reference(s)	SDG target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Transport				
KPI name	Traffic monitoring				
KPI No.	EC: ICT: T: 2C	Type:	Core	Type:	Smart
Definition/ Description	Percentage of major streets monitored by ICT				
Rationale/ Interpretation/ Benchmarking	Monitoring of major streets can allow for the implementation of services to better manage traffic congestion and traffic flow. Monitoring can be done using in-road sensors or cameras (or a combination of the two). Cities should report on major streets, which would include arterial roads and highways only. Residential streets should not be included. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: length of major streets monitored by ICT (km). Denominator: total length of major streets (km). Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected from municipal, regional or national transportation and roads departments.				
SDG reference(s)	SDG target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Transport				
KPI name	Intersection control				
KPI No.	EC: ICT: T: 3A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage of road intersections using adaptive traffic control or prioritization measures				
Rationale/ Interpretation/ Benchmarking	The use of adaptive traffic control or prioritization measures at intersections will allow for the traffic signals to respond to traffic patterns. Adaptive traffic control or prioritization includes measures such as embedded road sensors that change traffic signals based on actual vehicles flow or other similar sensors that provide the same function. This can lead to less idling time for cars at intersections and better traffic flow. Cities should report only on signal-controlled intersections. An increasing trend and higher values are considered positive.				
Methodology	Calculate as: Numerator: number of intersections with adaptive traffic control. Denominator: total number of signal-controlled intersections. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be obtained from local or national transportation / traffic authorities.				
SDG reference(s)	SDG target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Public sector				
KPI name	Open data				
KPI No.	EC: ICT: PS: 1A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage and number of inventoried open datasets that are published				
Rationale/ Interpretation/ Benchmarking	Open data can provide many benefits for cities and for its inhabitants. Open data government information, available as machine-readable open data, can facilitate government transparency, accountability and public participation in government. Open data can be seen as structured data that is machine-readable, freely shared, used and built on without restrictions. There are also benefits to be gained by opening government data sets to the public, so as to enable economic growth through technological innovation by the private sector. This will also help foster the development of new applications and services for inhabitants. An increasing trend and higher values are considered positive.				
Source(s)	NOTE – Open data principles. Retrieved from <http://open.canada.ca/en/open-data-principles#toc94>				
Methodology	Calculate as: Numerator: total number of open data sets published. Denominator: total number of data sets. Multiply by 100. For this indicator the numerator should also be reported.				
Unit	Percentage and number				
Data sources/ Relevant databases	Data can be collected through municipal ICT departments.				
SDG reference(s)	SDG target 16.6: Develop effective, accountable and transparent institutions at all levels. SDG target 16.7: Ensure responsive, inclusive, participatory and representative decision-making at all levels.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Public sector				
KPI name	e-government				
KPI No.	EC: ICT: PS: 2A	Type:	Advanced	Type:	Smart
Definition / Description	Number of public services delivered through electronic means				
Rationale/ Interpretation/ Benchmarking	E-government aims at improving the relationship between people and their government, through advanced electronic and mobile services. It aims at making public services delivery more effective, accessible and responsive to people's needs. It also aims at increasing participation in decision-making and making public institutions more transparent and accountable. Furthermore, the United Nations General Assembly has recognized the role of information and communication technology in promoting sustainable development and supporting public policies and service delivery. The United Nations General Assembly has also specifically affirmed the "potential of e-government in promoting transparency, accountability, efficiency and citizen engagement in public service delivery." Also, OECD countries support the idea that e-government can help improve efficiency in government and improve online access to information and service quality, enabling the delivery of services to citizens and businesses on their terms and at their convenience. This indicator focuses on the number of services available and can include websites, mobile applications, text messages, etc. An increasing trend and higher values are considered positive when in accordance with a city's strategy.				
Source(s)	NOTE 1 – United Nations E-government Survey 2020. Retrieved from <https://www.un.org/development/desa/publications/publication/2020-united-nations-e-government-survey> NOTE 2 – OECD. Implementing E-government in OECD Countries. Retrieved from: <http://www.oecd.org/mena/governance/36853121.pdf>				
Methodology	Calculate as: number of public services available through online service.				
Unit	Number				
Data sources/ Relevant database	Data can be collected through surveys of municipal departments/websites. NOTE – Information is also available through UN e-Government Development Index: <https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government>				
SDG reference(s)	SDG target 16.6: Develop effective, accountable and transparent institutions at all levels. SDG target 16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels.				

Dimension	Economy				
Sub-dimension	ICT				
Category	Public sector				
KPI name	Public sector e-procurement				
KPI No.	EC: ICT: PS: 3A	Type:	Advanced	Type:	Smart
Definition/ Description	Percentage of public sector procurement activities that are conducted electronically				
Rationale/ Interpretation/ Benchmarking	The movement of procurement transactions (bids, requests for proposal (RFP), invoices, payments) to electronic platforms can facilitate efficiency in government operations and allow for a wider base of suppliers to access potential government business. Cities should take into account all transactions that occur during the procurement process through various methods such as websites, web portals, mobile applications, etc. Cities that have moved a particular service to 100% electronic delivery can then use that as the basis for reporting. A higher value and an increasing trend are considered positive.				
Methodology	Calculate as: Numerator: number of public sector procurement activities conducted online. Denominator: total number of public sector procurement activities. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant sdatabase	Data can be obtained through city departments with procurement functions and IT departments.				
SDG reference(s)	SDG target 16.6: Develop effective, accountable and transparent institutions at all levels. SDG target 16.7: Ensure responsive, inclusive, participatory and representative decision-making at all levels.				

Dimension	Economy				
Sub-dimension	Productivity				
Category	Innovation				
KPI name	R&D expenditure				
KPI No.	EC: P: IN: 1C	Type:	Core	Type:	Structural
Definition/ Description	Research and development expenditure as a percentage of city GDP				
Rationale/ Interpretation/ Benchmarking	R&D is defined as research and development activities in natural sciences and engineering, social sciences and humanities and other inter-departmental disciplines. This includes any creative systematic activity undertaken to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications. R&D also includes fundamental research, applied research in such fields as agriculture, medicine, industrial chemistry, and experimental development work leading to new devices, products or processes. The Frascati Manual defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge (including knowledge of humans, culture and society), and the use of this stock of knowledge to devise new applications." Data collection methodology for this indicator could be adapted from the Frascati manual (an internationally recognized methodology for collecting R&D statistics). An increasing trend and higher values are considered positive.				
Source(s)	NOTE 1 – UNESCO Sustainable Development Goal 9.5. Retrieved from <http://uis.unesco.org/en/topic/sustainable-development-goal-9-5> NOTE 2 – UNECE. Promotion in Services Sector. Retrieved from <http://www.unece.org/fileadmin/DAM/ceci/publications/icp3.pdf> NOTE 3 – OECD Frascati Manual. Retrieved from <http://www.oecd.org/sti/inno/frascati-manual.htm>				
Methodology	Calculate as: Numerator: R&D expenditure (USD). Denominator: City GDP (USD). Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be sourced through municipal economics departments, business associations or through interpretation of national economic statistics.				
SDG reference(s)	SDG indicator 9.5.1: Research and development expenditure as a percentage of GDP.				

Dimension	Economy				
Sub-dimension	Productivity				
Category	Innovation				
KPI name	Patents				
KPI No.	EC: P: IN: 2C	Type:	Core	Type:	Structural
Definition/ Description	Number of new patents granted per 100 000 inhabitants per year.				
Rationale/ Interpretation/ Benchmarking	Patents demonstrate the efficacy of a country to turn research into products which can add value to end users. Healthy patent activity advances science and indicates the economic strength of a city. Patents enable inventors to profit financially and help businesses, researchers and academics advance in their field through information sharing. An increasing trend and higher values are considered positive and may indicate a more innovative urban environment.				
Methodology	Calculate as: Numerator: total number of new patents issued to residents and organizations of the city. Denominator: one 100 000th of the city's population.				
Unit	Number/100 000 inhabitants				
Data sources/ Relevant databases	Patents are granted by regional or national patent offices though some international bodies also track patents. Data can be found through organizations such as WIPO (World Intellectual Property Organization), national or regional patent offices, or through national research institutions.				
SDG reference(s)	SDG target 9.B: Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.				

Dimension	Economy				
Sub-dimension	Productivity				
Category	Innovation				
KPI name	Small and medium-sized enterprises				
KPI No.	EC: P: IN: 3A	Type:	Advanced	Type:	Structural
Definition/ Description	Percentage of small and medium-sized enterprises (SMEs)				
Rationale/ Interpretation/ Benchmarking	Organizations such as the European Commission, Asian Development Bank and World Bank consider SMEs important for ensuring economic growth, job creation, innovation, competition and social integration. Small and medium-sized enterprises (SMEs) are non-subsidary, independent firms which employ less than a given number of employees. This number varies across countries. The most frequent upper limit designating an SME is 250 employees, as in the European Union. However, some countries set the limit at 200 employees, while the United States considers SMEs to include firms with fewer than 500 employees. Small firms are generally those with fewer than 50 employees, while micro-enterprises have at most 10, or in some cases 5 workers. For this indicator cities should report on firms with fewer than 250 employees. An increasing trend and higher values are considered positive.				
Source(s)	NOTE – OECD Statistic. Retrieved from https://stats.oecd.org/glossary/detail.asp?ID=3123				
Methodology	Calculate as: Numerator: number of SMEs. Denominator: total number of enterprises. Multiply by 100.				
Unit	Percentage				
Data sources/ Relevant databases	Data can be collected through local, regional, or national business registration data.				
SDG reference(s)	SDG indicator 9.3.1: Percentage of small-scale industries with a total industry value added.				